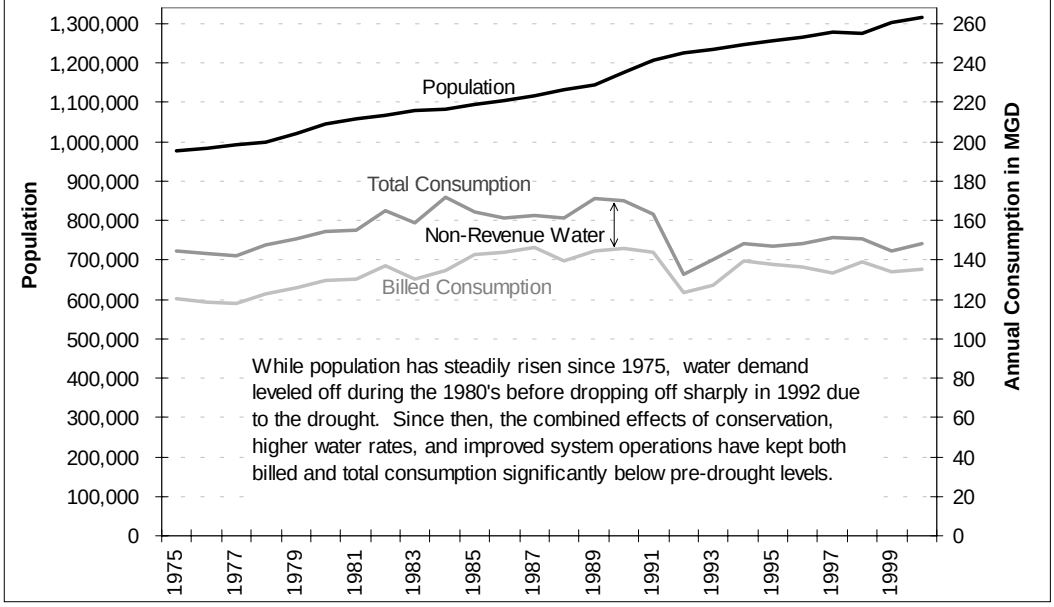
Section 2
Water Demand Forecast

A long-term forecast of water demand is a critical element in Seattle's water system planning process. Every two years, Seattle Public Utilities (SPU) updates its long-term forecast to reflect recent history and to incorporate new projections of demographic variables, rates, income, conservation, and other determinants of future water demand. The planning horizon for this WSP is 2001-2020. This Section summarizes trends in demand, provides Seattle's water demand forecast, and describes the forecasting methodology.

2.1 Trends in Demand and Population Served

SPU's retail and wholesale customer population has steadily risen since 1975. However, total water demand from Seattle's supply system leveled off during the late 1980s at about 170 million gallons per day (MGD), then dropped sharply in 1992 due to water use restrictions enacted during the unusually dry conditions experienced that year (Exhibit 2-1).

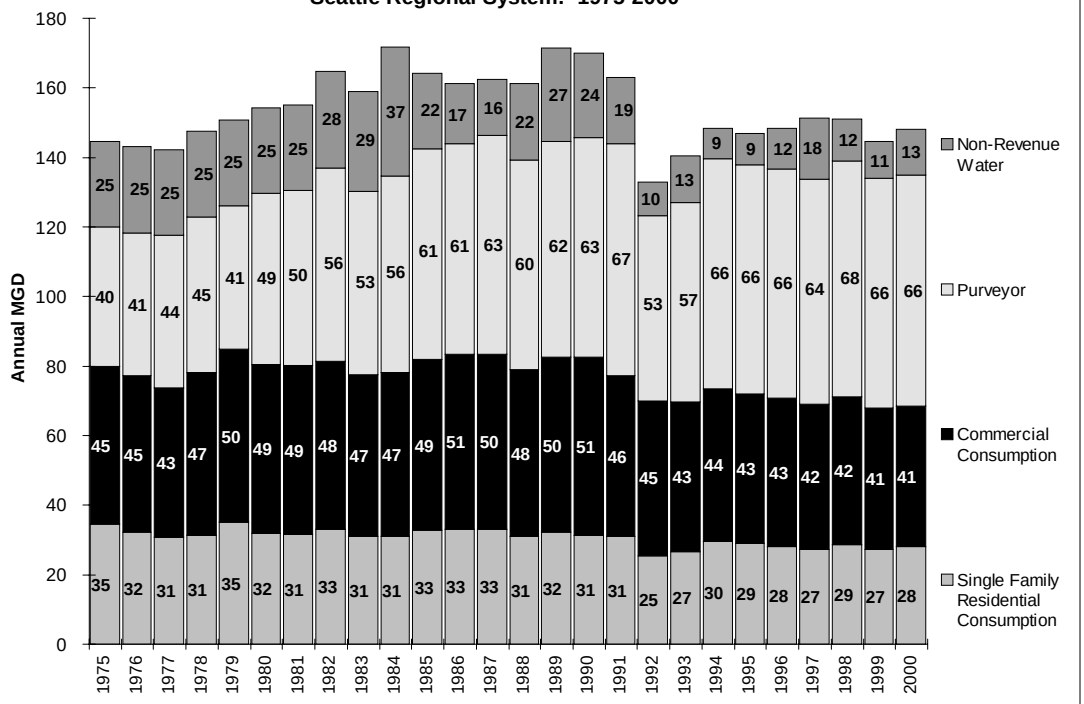
Exhibit 2-1
Growth in Population and Water Consumption
Seattle Regional Water System: 1975-2000



During the 1970s and 1980s, growth in water demand came primarily from Seattle's wholesale customers (Exhibit 2-2). Most of the area's growth in households and employment was occurring in the suburbs outside Seattle city limits and as a result, the volume of water sold wholesale by Seattle

increased by more than 50 percent: from 40 MGD in 1975 to 67 MGD in 1991. In the same period, residential and commercial water demand inside Seattle, as well as non-revenue water,[1] remained relatively flat.

Exhibit 2-2
Components of Annual Water Demand
Seattle Regional System: 1975-2000



After the 1992 drought, conservation and higher water rates combined to halt the growth in purveyor demand while actually reducing demand within Seattle. Meanwhile, non-revenue water was cut in half through various improvements in system operations made by the City. These changes to system operations include (1) discontinuing Green Lake flushing, (2) significantly reducing reservoir overflowing, (3) ceasing turbine overflows at SW Trenton, (4) relining Maple Leaf and Roosevelt reservoirs, (5) rehabilitating/replacing other reservoirs, and (6) improving reservoir washing practices.

Since then, the combined effects of higher water rates, conservation, and improved system operations have kept both billed and total consumption significantly below pre-drought levels. Since 1994, annual demand has remained around 150 MGD despite continued population growth (Table 2-1). This is a drop of 20 MGD or 12 percent from pre-drought levels of consumption. Consumption *per capita* has continued to decline and is now approximately 20 percent below pre-drought levels (Exhibit 2-3).

[1] Non-revenue water is water that is produced but not sold. Causes of non-revenue water include system operations (main flushing, reservoir cleaning), fire fighting, street cleaning, pipeline/reservoir leaks, and slow customer meters.

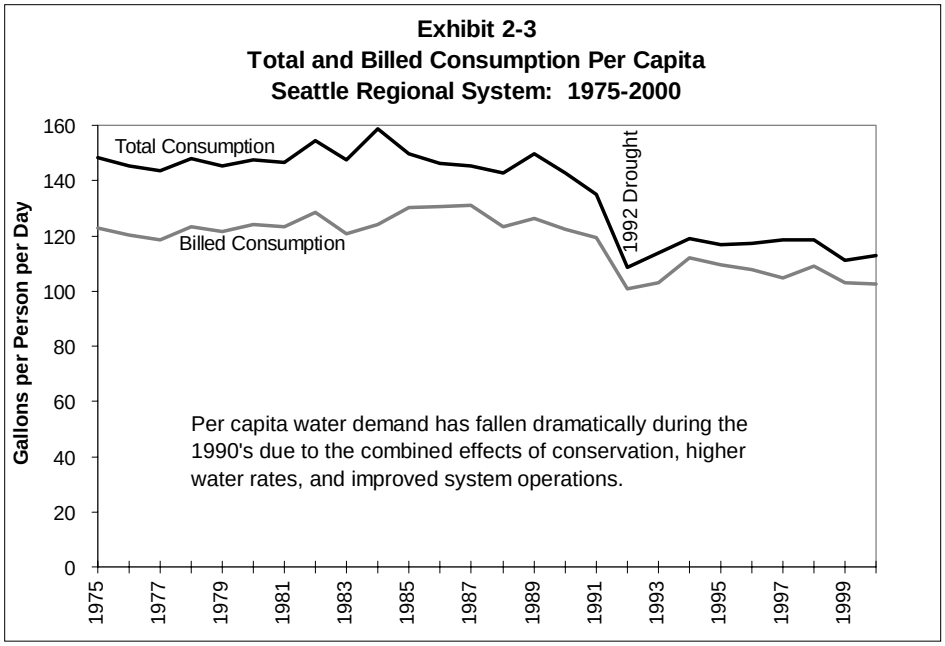
Table 2-1
Water System Statistics

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
A. Service Information										
# persons served directly by Seattle	567,300	574,000	579,100	581,600	584,100	585,700	586,800	588,900	592,200	594,800
# persons served by wholesalers	621,200	633,600	645,900	652,000	658,200	664,000	667,300	674,200	682,600	686,600
Total # of persons served	1,188,500	1,207,600	1,225,000	1,233,600	1,242,300	1,249,700	1,254,100	1,263,100	1,274,800	1,281,400
# of wholesale providers (service districts, cities, towns)	30	30	29	28	28	28	28	27	27	27
B. Water Use										
Total water diversions – daily average (MGD)	170.1	163.2	132.8	140.5	148.9	146.9	148.5	150.6	151.0	144.7
Billed – average daily use for area (MGD)	145.8	144.0	123.2	127.1	139.5	137.7	136.6	133.7	139.1	134.0
Billed – average daily use per person (gallons)	122.7	119.2	100.6	103.1	112.3	110.2	108.9	105.8	109.1	104.6
Non-revenue water (MGD)*	24.3	19.2	9.5	13.4	9.3	9.2	11.9	16.9	11.8	10.7
Non-revenue water as % of total diversions	14.3%	11.7%	7.2%	9.5%	6.3%	6.3%	8.0%	11.2%	7.8%	7.4%
C. Number of Retail Connections (Meters)	170,094	170,570	171,098	171,806	172,203	172,730	173,230	173,617	174,193	174,672

MGD = Million gallons per day

* Non-revenue water does not include purveyor distribution non-revenue water. See page 2-12 for further discussion.

Exhibit 2-3
Total and Billed Consumption Per Capita
Seattle Regional System: 1975-2000



2.2 The 1999 Demand Forecast

2.2.1 Seattle and Current Wholesale Customers

The current water demand forecast for Seattle and its existing wholesale customers was produced in 1999 and is shown in Exhibit 2-4 and Table 2-2. It includes demands for all of the wholesale customers listed in Table 1-2, with the exception of Covington. Covington only recently became a wholesale customer, and is treated in the demand forecast as a "new wholesale customer." The new forecast projects significantly less demand than either the 1993 Water Supply Plan forecast or the more recent 1997 forecast.

The forecast in the 1993 Water Supply Plan correctly predicted that water demand would actually decline during the 1990s due to the impact of programmatic, plumbing code, and rate-induced conservation. Actual demand fell even more than predicted however, as numerous improvements in system operations reduced non-revenue water by much more than expected. This lower level of non-revenue water was incorporated into the model along with many other changes when the forecast was revised in 1997.

Exhibit 2-4
Old and New Forecasts of Water Demand: 1994-2020
(Current Retail and Wholesale Customers, Average Annual MGD)

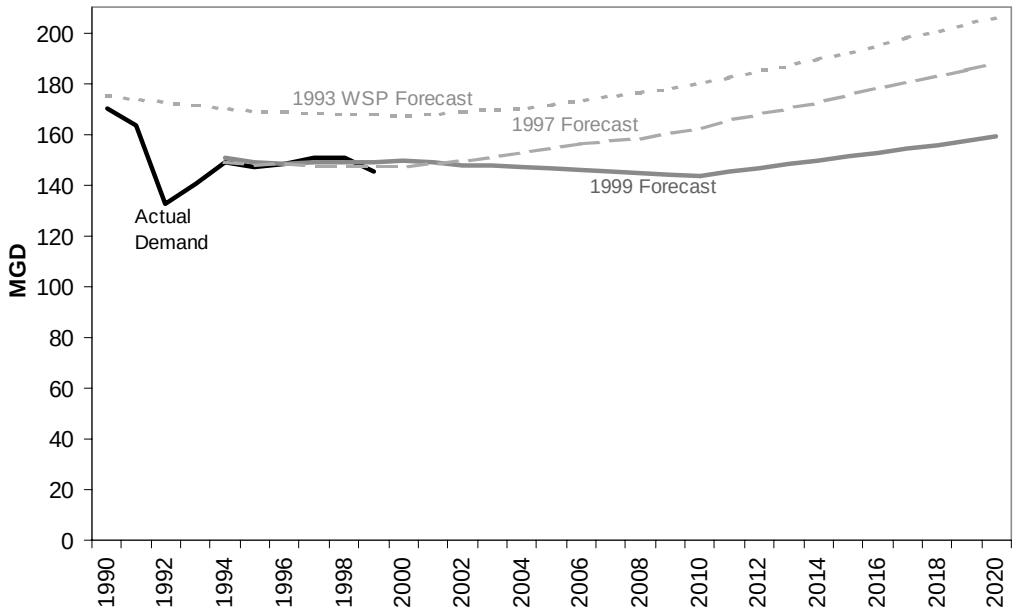


Table 2-2
Components of the Water Demand Forecast: 1995-2020
(In Average Annual MGD)

	Seattle Retail		Current Purveyors		System
	Billed	Non-Revenue	Billed	Non-Revenue	Total
1995	72	9	66	2	149
2000	71	10	67	2	150
2005	69	9	66	2	146
2010	67	9	66	2	144
2015	70	8	71	2	151
2020	74	7	76	2	159

Reflecting the expected impact of the 1% Conservation Program, total water demand is projected to drop from 149 MGD in 1999 to 144 MGD in 2010.

The new 1999 forecast is lower still, reflecting the expected impact of the 1% Conservation Program. Because of this program, total water demand is projected to actually decline slightly in the next ten years, dropping from 149 MGD in 1999 to 144 MGD in 2010. After 2010, demand is forecast to increase but not as quickly in the 1997 forecast. It is assumed that within the retail service area, continued investment in conservation will be made to maintain the reduction in per-capita consumption achieved through the 1% Conservation Program. It is also assumed that no additional conservation programs will be implemented after 2010 in the wholesale service area so demand in that sector is expected to grow faster than the underlying growth in population, driven by the effects of rising real

household income and declining household size. As a result, total demand is forecast to reach 159 MGD by 2020..

2.2.2 New Wholesale Customers

All the forecasts above apply to the retail and wholesale customers that SPU currently serves. However, SPU is including some new or potential customers in the demand forecast for this plan. Issaquah and Covington are new wholesale customers that have recently signed contracts to get water from Seattle in the future. North Bend, Sallal, Ames Lake, Union Hill[2], Water District 111 and Sammamish Plateau are potential wholesale customers that have expressed interest in water from the Seattle system in the future. Issaquah recently became an indirect wholesale customer when it signed a contract with Bellevue to purchase up to 1.7 MGD. Covington recently signed a contract directly with Seattle to meet its demand in excess of its own supply resources. The others are still in the discussion stage with Seattle. Total sales to all the above utilities could reach a maximum of 11 MGD by 2020. If Tacoma's Second Supply Project (SSP) comes online, it is assumed that Covington would discontinue its purchases from Seattle. In that case, the maximum 2020 demand from the rest of the new wholesale customers would be 7 MGD rather than 11 MGD.

Forecasts of total system demand with and without new/potential wholesale customers, and with and without the Second Supply Project, are shown in Table 2-3 and Exhibit 2-5.

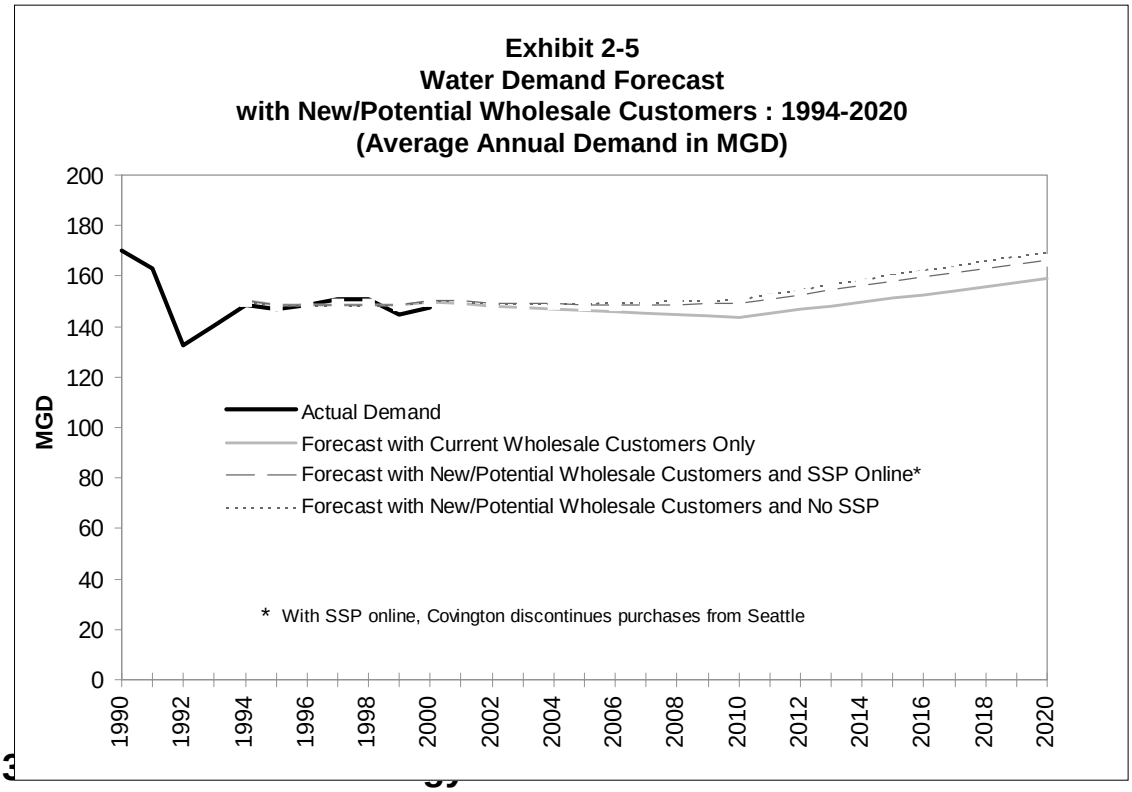
Table 2-3
Forecasts of Total System Demand with Current and New/Potential Wholesale Customers
(In Average Annual MGD)

	Total for Current Customers Only	Sales to Potential/New Customers		Total with New Customers	
		With SSP*	Without SSP	With SSP*	Without SSP
1995	149	0	0	149	149
2000	150	1	1	151	151
2005	146	2	3	148	149
2010	144	5	7	149	151
2015	151	7	9	158	160
2020	159	7	11	166	170

* With the Second Supply Project online, it is assumed that Covington discontinues purchases from Seattle.

[2] Union Hill currently buys water from Seattle indirectly through Redmond and its demand is already reflected in SPU's forecast of demand from current customers. Granting Union Hill purveyor status will therefore not increase demand on the Seattle system.

Exhibit 2-5
Water Demand Forecast
with New/Potential Wholesale Customers : 1994-2020
(Average Annual Demand in MGD)

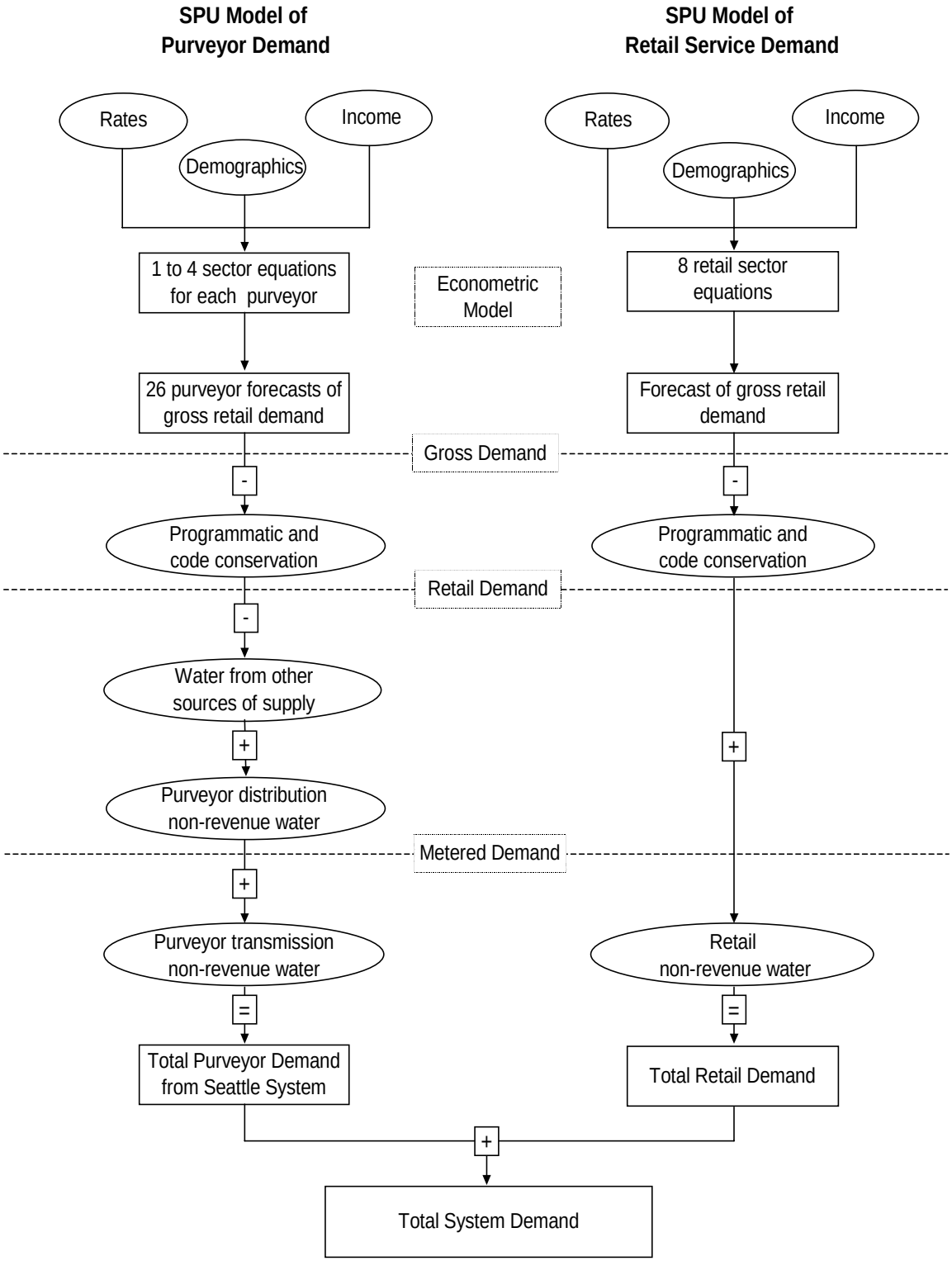


2.3.1 The Model

In the early 1990s, the Seattle Water Department and the East King County purveyors jointly developed an econometric model which was used to forecast regional water demand in the 1993 Water Supply Plan. Water demand was classified by customer type and then, using historical data, the impact of water rates, household income, weather, and the number of households or employees on sector demand was estimated. The model then used forecasts of these "explanatory" variables to forecast gross water consumption by sector.

The entire model consists of 77 separate forecasts of retail water demand, one for each customer class in each of 28 different geographic areas (inside and outside Seattle City limits for retail customers, plus 26 purveyors, not including Covington). These forecasts are then summed to obtain total gross demand for retail customers and for purveyors. Conservation savings (code and programmatic) and purveyor sources of supply are subtracted from total gross demand. Finally, non-revenue water is added to obtain the forecast of total system demand. This is shown in simplified schematic form in Exhibit 2-6.

Exhibit 2-6
Components of the Water Demand Forecast Model



2.3.2 The 1997 Forecast Methodology

The 1997 forecast utilized the same basic model, recalibrated to actual 1994 consumption with all of the explanatory variables (demographics, prices, income, conservation savings, non-revenue water, and other sources of purveyor supply) updated with historical data through 1996 and new projections of their future values. Sources for the specific model inputs are summarized below:

- *Demographic Growth:* Puget Sound Regional Council (PSRC) forecast of households and employment adopted in 1995.
- *Household Income:* Seattle City Light Long Range Economic & Demographic Forecast, 1995.
- *Water & Sewer Rates:* Actual through 1996. Growth through 2001 as projected in the 1996 Rate Study. Constant in real (i.e., inflation-adjusted) terms thereafter.
- *Non-Revenue Water:* Actual through 1996. Approximately 10% of total system demand thereafter.
- *Conservation Savings:* Programmatic and code savings estimated by SPU conservation staff. (This was prior to the Conservation Potential Assessment and the 1% Conservation Program.)

2.3.3 The 1999 Forecast Methodology

The handling of conservation is the biggest change in the 1999 update. In the past, estimates of conservation savings were based on an analysis of the impact of specific conservation programs, both existing and planned, plus the 1993 State Plumbing Code. The result was a forecast of the amount of water saved each year through conservation. This forecast was subtracted from the forecast of gross demand to obtain net retail demand.

The Conservation Program is a commitment to implement a cost effective package to meet a pre-set goal of 1% per year.

The methodology used in the 1999 forecast is very different due to the nature of the 1% Conservation Program. The 1% Conservation Program is not a set investment in conservation, but rather a commitment to implement the package of cost-effective programs identified in the Water Conservation Potential Assessment, at whatever intensity is necessary to achieve the goal of reducing per capita consumption by 1% a year for ten years. For the 1999 forecast, it is assumed that the 1% Conservation Program is implemented and its goals are met. The forecast is therefore disconnected from the econometric model for the period 2000-2010 and a "per capita" methodology is used to forecast demand in that period.

The Per Capita Methodology. Demand during the period of the 1% Conservation Program is forecast as follows: Per capita retail demand factors in the year 2000 are calculated separately for the retail and wholesale customers. For each year of the ten-year program period, the per capita demand factors are reduced by 1% of the original demand

factors. The new demand factors are then multiplied by each year's PSRC population forecast to obtain the forecast of retail demand. For retail demand, non-revenue is added to obtain total retail service demand. On the purveyor side, other sources of supply are subtracted before adding non-revenue water.

After 2010. During development of the Water System Plan the level of investment in conservation that will follow the 1% Conservation Program had not been determined. Therefore, several different scenarios were used to initially forecast water demand after 2010. Scenario 1 assumed that no additional conservation would be implemented following the 1% Conservation Program. Retail demand was assumed to grow at the same rate as in the underlying econometric model forecast. In Scenario 2, conservation after 2010 was designed to maintain the same level of per capita consumption attained through the 1% Conservation Program[3]. Therefore, the forecast kept per capita retail demand constant from 2010 on. Scenario 3 subtracted the remaining conservation savings (after deducting the savings already achieved by the 1% Conservation Program) that could be produced by the CPA's "technical potential"[4] conservation package from the Scenario 1 forecast of 2020 demand.

In November 2000, the Seattle City Council adopted a resolution committing SPU to implementing the remainder of the "cost effective" conservation package (as identified in the Conservation Potential Assessment) upon the completion of the 1% Conservation Program. This would take place between 2010 and 2020 within the retail service area only. For this reason, the three post-2010 scenarios described above have been replaced with a single scenario in which per capita demand in the retail sector is held constant at the level attained by 2010 but wholesale demand grows at the same rate as the underlying econometric model forecast. This produces a forecast of 2020 demand about half way between scenarios 1 and 2. Demand for the existing retail and wholesale customers would increase from 144 MGD in 2010 to 159 MGD in 2020.

The Econometric Model. The econometric model provides a base for the "per capita" forecast as well as the rate of growth in demand after 2010 for Scenarios 1 and 3. However, the model has not been updated since 1997 even though new model inputs have become available. This is because the new inputs have not changed enough to alter the forecast. New PSRC forecasts of household and employment growth are almost identical to PSRC's 1995 projections (PSRC, 1995). Similarly, the latest forecast of growth in household income is no different than the 1995 projection used

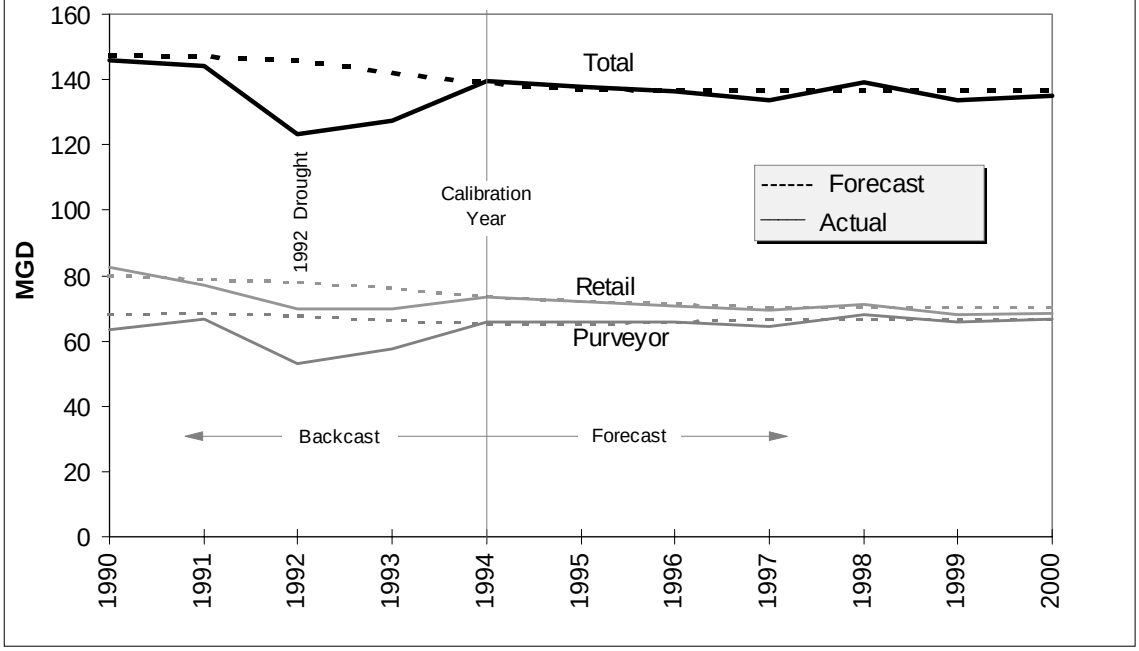
[3] This is roughly equivalent to completing the remaining programs in the "cost effective conservation package" as identified in the CPA.

[4] This package is defined in Seattle's Water Conservation Potential Assessment (CPA) as all measures, regardless of cost, that could be implemented over the next 20 years without a loss of service or satisfaction to the customer.

in the 1997 demand forecast. Another reason for using the 1997 forecast as a foundation for the new forecast is its performance compared to actual demand. As can be seen in Exhibit 2-7, the 1997 forecast of billed consumption has tracked actual consumption quite closely. (Note that the forecast is calibrated to 1994.)

The econometric model does not use equivalent residential units (ERUs) but rather single family households, multifamily households, and employment by sector. The per capita model uses population. Forecasts of these demographic variables, classified by Transportation Analysis Zone (TAZ), are obtained from PSRC. The TAZ level data are allocated to the service areas of Seattle and each of its purveyors. The resultant service-area-specific forecasts serve as the model inputs and are displayed in Table 2-4.

Exhibit 2-7
Comparison of Forecast and Actual Billed Consumption: 1990-1999



In the early 1990s, the Seattle Water Department (now incorporated in SPU) took a number of actions to reduce the amount of water used in operating the system.

Non-Revenue Water. Seattle system non-revenue water is calculated by subtracting total metered sales (both retail and wholesale) from total water diversions. Conceptually, it consists of non-revenue water within the retail distribution area plus that associated with the regional transmission system. Non-revenue water within purveyors' own distribution systems is not included as Seattle system non-revenue water because, while it is non-revenue to purveyors, it is revenue water to Seattle.

Table 2-4
Forecasts of Population, Households and Employment
1999-2020

	Population			Single Family Households		
	Retail Service	Wholesale	Total	Retail Service	Wholesale	Total
1999	594,426	600,356	1,194,782	149,930	163,722	313,652
2000	597,179	610,239	1,207,418	150,260	165,256	315,516
2005	615,914	643,829	1,259,743	151,210	175,741	326,951
2010	635,238	679,268	1,314,506	152,166	186,890	339,056
2015	663,749	721,238	1,384,987	152,985	191,875	344,860
2020	693,541	765,801	1,459,342	153,809	196,993	350,802
Annual Growth Rates						
2000-10	0.6%	1.1%	0.9%	0.1%	1.2%	0.7%
2010-20	0.9%	1.2%	1.1%	0.1%	0.5%	0.3%

	Multifamily Households			Employment		
	Retail Service	Wholesale	Total	Retail Service	Wholesale	Total
1999	128,111	76,435	204,546	553,111	324,583	877,694
2000	130,210	78,204	208,414	558,740	330,016	888,756
2005	146,725	89,164	235,889	596,611	359,945	956,556
2010	165,335	101,660	266,995	637,048	392,589	1,029,637
2015	182,095	116,892	298,987	655,238	419,277	1,074,515
2020	200,555	134,405	334,960	673,947	447,778	1,121,725
Annual Growth Rates						
2000-10	2.4%	2.7%	2.5%	1.3%	1.8%	1.5%
2010-20	1.9%	2.8%	2.3%	0.6%	1.3%	0.9%

Changes in the forecast of non-revenue water affect the new demand forecast. In the early 1990s, the Seattle Water Department (now incorporated in SPU) took a number of actions to reduce the amount of water used in operating the system. As a result, non-revenue water was reduced by more than 60 percent. Between 1992 and 1995, non-revenue water had dropped to as low as 9 MGD and was averaging 10 MGD or about 7 percent of total consumption.

Based on this experience, non-revenue water was forecast to be about 7 percent of total consumption in the 1997 forecast. Recently, however, non-revenue water has risen slightly, to about 12 MGD. This is due to management of the system to meet water-quality objectives. Most of the actions taken to reduce non-revenue water (such as repairing leaky reservoirs, eliminating the flushing of Green Lake, and switching to high pressure washers for reservoir cleaning) resulted in permanent reductions in non-revenue water. However, water quality considerations determine the frequency of reservoir cleaning and the quantity of water used for main flushing and reservoir overflowing, all of which contribute to non-revenue water. The goal is to use only as much water as necessary to maximize water quality. In the last few years, water operations staff have determined that this goal can be achieved by using 3 to 4 MGD for system operations (as outlined below). This is consistent with total non-revenue water of about 12 MGD.

As Seattle's distribution reservoirs are covered and, to a lesser extent, the Tolt Treatment Facility comes online, the need for reservoir cleaning and

overflowing will greatly diminish. Reservoir leaks and evaporation will also be much reduced. Based on experience during and following the 1992 drought, water operations staff estimate that non-revenue water could be reduced by about 3 MGD by the time all the reservoirs are covered. Since the reservoir-covering program is scheduled to be complete by 2020, the forecast of non-revenue water in the new demand forecast starts out at 12 MGD in the year 2000 and drops to 9 MGD by 2020.

Non-revenue water has a number of causes including (1) normal operation of the water system, (2) public uses (fire fighting, street cleaning, construction), (3) losses (system leakage, net evaporation from open reservoirs), and (4) metering inaccuracies. Accounting for how much non-revenue water is used or lost in these various ways is difficult because the water is not or cannot be metered. However, some categories of non-revenue water have been estimated making it possible to provide at least a rough breakdown. This is summarized in Table 2.5, below.

Table 2-5
Components of Non-Revenue Water

Total Non-Revenue Water	**12.0 MGD**
System Operations	**3.3 MGD**
Reservoir Overflowing	1.2 MGD
Reservoir Draining/Cleaning	2.0 MGD
Watermain Flushing	>0.1 MGD
Public Uses	**0.3 MGD**
Construction	>0.1 MGD
Sewer Flushing, Fire Fighting, Street Cleaning, etc.	0.2 MGD
Meter Inaccuracies	**2.0 MGD**
System Losses	**6.4 MGD**
Measured Losses (Reservoir Leaks/Evaporation	0.8 MGD
Unmeasured Losses (Pipeline Leaks and Other)*	5.6 MGD

* All the categories except unmeasured losses were estimated by water service, operations, and metering staff. Unmeasured losses were calculated by subtracting the estimates for all other types of non-revenue water from total non-revenue water. To the extent the estimates for all other types of non-revenue water are (on average) too low, the estimate of unmeasured losses will be too high, and vice versa.

New Wholesale Customers. Eight new/potential wholesale customers provided forecasts of their total demand and information about their current supply capacity. Their demand from the Seattle system were estimated by taking the difference between their demand projections and their current supply, subject to whatever limits are placed on their purchases. Issaquah's demand from Seattle is subject to a cap of 1.7 MGD. Sales to Covington will *not* be subject to a cap but are expected to cease at the completion of Tacoma's Second Supply Project. Forecasts of possible water sales to the eight new/potential wholesale customers are shown in Table 2-6.

Table 2-6
Forecast Possible Water Sales to New/Potential Wholesale Customers
(in Average Annual MGD)

	Issaquah	Sammamish Plateau	Ames Lake	Union Hill[(1)]	North Bend	Sallal	Covington[(2)]	WD 111
2000	0.0			0.1	0.0		0.5	
2001	0.1			0.1	0.2		0.6	
2002	0.2	0.0		0.2	0.3		0.7	0.0
2003	0.3	0.2		0.2	0.3		0.8	0.1
2004	0.4	0.5		0.2	0.3		0.9	0.2
2005	0.5	0.8		0.2	0.3		1.0 / 0.0	0.3
2006	0.8	0.9		0.2	0.4	0.0	1.1 / 0.0	0.5
2007	1.0	1.1		0.2	0.4	0.0	1.2 / 0.0	0.6
2008	1.2	1.3	0.0	0.3	0.5	0.1	1.4 / 0.0	0.7
2009	1.4	1.5	0.0	0.3	0.5	0.1	1.5 / 0.0	0.8
2010	1.7	1.7	0.0	0.3	0.5	0.1	1.6 / 0.0	0.9
2011	1.7	1.8	0.0	0.3	0.6	0.1	1.8 / 0.0	1.0
2012	1.7	1.9	0.0	0.3	0.6	0.2	2.0 / 0.0	1.1
2013	1.7	2.0	0.0	0.4	0.6	0.2	2.2 / 0.0	1.2
2014	1.7	2.0	0.1	0.4	0.6	0.2	2.4 / 0.0	1.3
2015	1.7	2.0	0.1	0.4	0.6	0.3	2.6 / 0.0	1.4
2016	1.7	2.0	0.1	0.4	0.7	0.3	2.9 / 0.0	1.6
2017	1.7	2.0	0.1	0.4	0.7	0.3	3.1 / 0.0	1.7
2018	1.7	2.0	0.1	0.4	0.7	0.4	3.4 / 0.0	1.8
2019	1.7	2.0	0.1	0.4	0.7	0.4	3.6 / 0.0	1.9
2020	1.7	2.0	0.1	0.4	0.7	0.4	3.7 / 0.0	2.0

(1) Union Hill's demand for water in excess of its own supply is already included in the forecast of demand from Seattle current customers and is listed in this table only to show that utility's demand on the system.

(2) Covington's demand for water in excess of its own supply is expected to grow to 3.7 MGD by 2020. It is assumed, however, that Covington will discontinue its purchases from Seattle and switch to Tacoma's Second Supply Project if it is completed.

2.4 Comparison of Demand Forecast with Firm Yield Estimate

The current firm yield (98% reliability, Section 4) of Seattle's supply resources is 160 MGD, soon to increase to 171 MGD when the Tolt Treatment Facility is completed. The Second Supply Project is expected to bring an additional 14 MGD into the system for a total of 185 MGD. Combining these estimates of firm yield with the new demand forecasts reveals that SPU has sufficient supply to meet the projected demand forecast through the planning horizon of this WSP. Exhibit 2-8 shows the

demand forecast for Seattle's current retail and wholesale customers plus the incremental demand of the eight new/potential wholesale customers, with the Second Supply Project (SSP). Exhibit 2-8 shows the forecast with savings from the commitment the Seattle City Council made to continued conservation in the retail service area after 2010. Even without the Second Supply Project, SPU is expected to have sufficient supply capacity to meet forecast demand for both existing and new customers beyond 2020 with the continued investment in programmatic conservation after 2010, as seen in Table 2-7.

Exhibit 2-8
Firm Yield Estimates and Forecasts of Water Demand
(in Average Annual MGD)

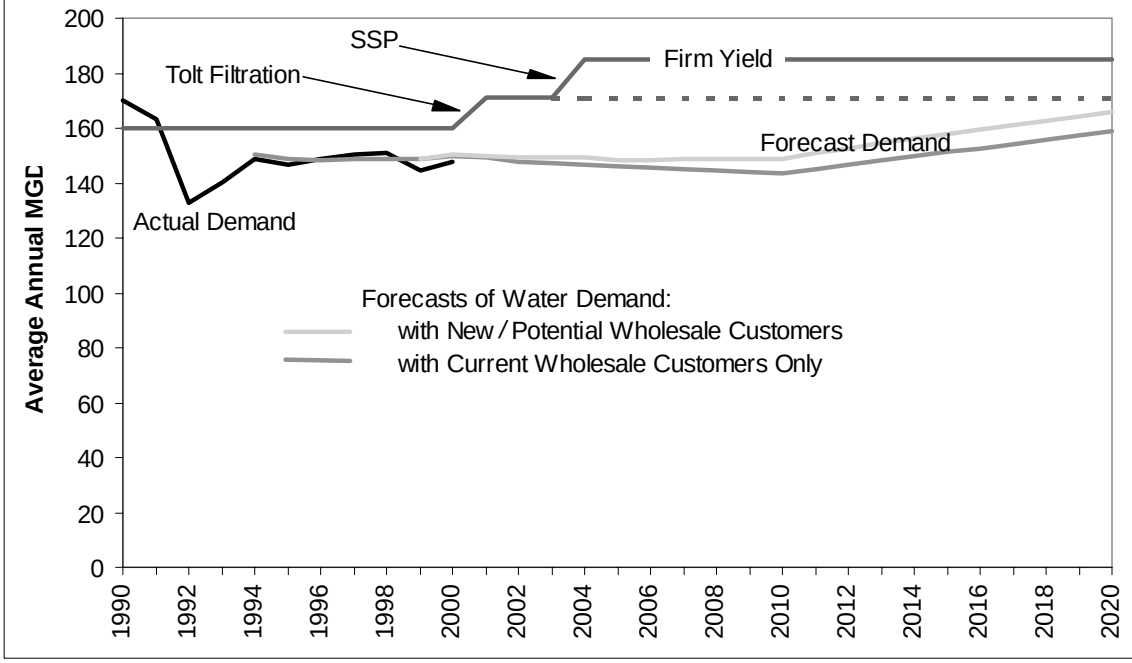


Table 2-7
Year When Demand Equals Firm Yield

Customers Served	w/ SSP	w/o SSP
Retail and Current Wholesale Customers	2035	2018
With new/potential wholesale customers	2031	2021